FROM ADOLESCENT SCHOOLING TO ADULT HEALTH: SCHOOL EXPERIENCES, CONTEXTUAL DISADVANTAGE, AND INFLAMMATION

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ABSTRACT

Kristen M. Schorpp: From Adolescent Schooling to Adult Health: School Experiences, Contextual Disadvantage, and Inflammation
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Extensive research has identified the widespread benefits of positive academic and social experiences on adolescent well-being, but it remains unknown whether such experiences within the school context affect future physiological functioning. Using data from the National Longitudinal Study of Adolescent Health (1994-2006), this study examined the longitudinal relation between adolescent school experiences, school contextual disadvantage, and a physiological indicator of inflammation (C-reactive protein) in young adulthood. Results from ordinal logistic regression analysis provide evidence for the protective effect of academic achievement, cognitive aptitude, and extracurricular involvement on young adult C-reactive protein levels. Furthermore, school-level socioeconomic disadvantage moderated these associations, such that adolescents in contexts of high socioeconomic disadvantage experienced greater benefits from high academic achievement and school connectedness compared to adolescents in schools of lower socioeconomic disadvantage. These results are the first to identify the significant relation between adolescent schooling and physiological functioning, and also illuminate the potential for positive school experiences to promote individual resilience among adolescents in disadvantaged school contexts.

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LIST OF ABBREVIATIONS

CRP	C-reactive Protein
hs-CRP	High-sensitivity C-reactive Protein
Add Health	National Longitudinal Study of Adolescent Health
GPA	Grade Point Average
AHPVT	Add Health Picture Vocabulary Test

INTRODUCTION

The experiences that adolescents encounter within school are critical for individual development and well-being. Secondary school provides cognitive, academic, and social resources that influence the formation of educational and career goals (Ross & Mirowsky 1999) and aid in the development of interpersonal skills necessary to effectively manage the daily stressors of adolescent life (Bond et al. 2007; McNeely & Falci 2004). Furthermore, mounting evidence suggests that success in school, both academically and socially, is a key contributor to future status attainment and social adjustment as adolescents enter adulthood (Wilson & Portes 1975; Chen & Kaplan 2003; Harris & Lee 2012).

Despite the widespread gains that positive educational experiences appear to provide, very little research has investigated the lasting influence that adolescent schooling has on young adult health. Most studies that assess the effects of adolescent school experiences focus on social, educational, and economic outcomes rather than physical health, and no studies to date use physiological health measures to investigate these relations. Indicators of physiological dysregulation are especially informative because they provide an objective assessment of health status and illuminate the underlying biological processes that link social conditions to observable health outcomes. In addition, most studies on adolescent schooling do not provide a comprehensive assessment of schooling that captures both academic and social domains of adolescent experience. A focus on only one or the other fails to account for the diversity of positive and negative adolescent school experiences that have the potential to affect later well-

being. Finally, the role of school contextual disadvantage in affecting the relation between schooling and physical health outcomes is unknown. Ecological perspectives of human development emphasize the interactive nature of individual experiences with the opportunities and limitations afforded by the school environment (Bronfenbrenner 1977), which illuminates the potential of school context to influence individual trajectories in physical health.

Based on the concepts described above, my research used a life course epidemiology perspective to (1) investigate whether academic and social domains of adolescent school experience were predictive of a physiological health indicator in young adulthood; and (2) determine if school-level disadvantage, as assessed by aggregates of student socioeconomic background, moderated individual associations between school experiences and health. The data come from the National Longitudinal Study of Adolescent Health (Add Health). Add Health includes in-school surveys that probe adolescent achievements, aptitudes, and perceptions school social and academic experience, as well as contextual information that captures the school-level conditions that have the capacity to influence adolescent well-being. High-sensitivity C-reactive protein (hs-CRP) was used as a physiological indicator of chronic inflammation. CRP is a strong candidate for identifying the physiological basis for the relationship between educational experience and health outcomes because inflammation has been implicated as a critical underlying process linking social conditions to the emergence of several common chronic illnesses (e.g., Yang et al. 2013).

Applying a biosocial approach to the relationship between schooling and health contributes to current understandings of the lasting role of adolescence on individual well-being. Adolescence is often conceptualized as a sensitive period for both social and biological change, suggesting that experiences within this developmental stage may have a lasting impact on

individual trajectories in health and well-being. Furthermore, an assessment of young adult physiological health outcomes examines whether health disparities based on adolescent experiences exist before the chronic conditions associated with physiological dysregulation typically emerge. Collectively, this study provides further insight in the social, contextual, and biological processes that contribute to individual health across the life course.

BACKGROUND AND THEORY

Adolescent Schooling and Health: A Life Course Epidemiology Approach

Education is a significant predictor of future health: adults that are more educated experience better mental health, fewer chronic conditions with age, and increased longevity compared to those with lower educational attainment (Herd 2010; Loucks et al. 2006; Ross & Mirowsky 1999; Resnick et al. 1997). Social epidemiological research implicates several interrelated pathways in explaining health disparities based on educational attainment, including health behaviors, differential exposure to daily stressors, and the availability of social and economic resources in adulthood (Bond et al. 2007; Harris & Lee 2012; Ross & Mirowsky 1999).

But how early in the life course do educational experiences become significant for future health? Fundamental to the life course epidemiology framework is the notion that social, biological, and contextual factors at developmentally sensitive periods influence physical health across the life course (Ben-Shlomo & Kuh 2002), emphasizing the need to investigate the lasting impact of life experience during early-life developmental transitions. Adolescence has increasingly been conceptualized as a sensitive period characterized by both social and physiological developmental processes. Still, studies assessing the relation between education and health often rely on educational attainment as a primary indicator (Herd et al. 2007; Ross & Mirowsky 1999), which is typically acquired by young adulthood and fails to capture the more nuanced aspects of the schooling experience that are particularly important for individual well-

being. Very little attention has been given to the impact of adolescent school experiences on future health and illness despite the importance of adolescence on social and cognitive development. Rapid social and contextual changes occur during adolescence, including an increased reliance on peer and school contexts for social interaction and the development of self-concept (Steinberg & Morris 2001). In tandem with these social changes, adolescents experience rapid development and reorganization of brain areas that regulate emotional and behavioral processes, suggesting that adolescent experiences may have a lasting influence on emotional, cognitive, and social aptitude (Steinberg 2005; Andersen & Teicher 2008; Blakemore & Choundhury 2006; Sisk & Zehr 2005). These mutually-reinforcing social and physiological pathways of individual development suggest the primary importance of adolescent schooling in developing the social, cognitive, and behavioral skills that contribute to better health in adulthood. Based on the concept of sensitive periods that is central to life course epidemiology, I argue that school experiences during adolescence are critical for the development of cognitive and social skills that contribute to health in young adulthood. From an academic standpoint, schools are thought to provide the cognitive capital (i.e., learned content knowledge, problem-solving skills, and the development of abstract thinking) that influences the formation of future goals and achievements, promotes better health behaviors, and enhances the use of positive coping resources due to a higher sense of personal autonomy (Ross & Mirowsky 1999). A recent study by Herd (2010) identified the importance of high school academic performance on later health outcomes, finding that high school grade point average mediated the associations between educational attainment and both self-reported health and chronic conditions in late life. This study reveals that the benefits of education do not function solely through educational attainment, but also hinge upon academic performance in adolescence.

It is also not understood when disparities in health based on education begin to emerge. Because the adverse health outcomes that are classically studied in relation to educational experiences and attainment (i.e., cardiovascular disease, dementia, mortality) are almost exclusively observed in older adults, prior educational research primarily focuses on health long after the completion of schooling. However, the imprints of educational disparities may already be apparent in young adulthood through indicators of physiological functioning, such as CRP. Prior research has identified a significant relation between educational attainment and inflammation in old age (Loucks et al. 2006; Ranjit et al. 2007), but none have investigated the effects of education on inflammatory functioning among younger populations. Observation of underlying biological processes allows for assessment of health risk in young adulthood, which is often long before the emergence of illness symptomology.

My first hypothesis builds upon current understandings of adolescent schooling and later health outcomes to examine the relation between adolescent academic experiences and young adult physiological functioning:

> Hypothesis 1: Higher academic achievement and cognitive aptitude will be predictive of better health as indicated by reduced odds of elevated CRP in young adulthood.

Beyond academics, schools also act as a significant forum for social development. Schools provide adult support through teachers and school staff, peer support through classmates, and the opportunity to participate in extracurricular activities that foster the development of academic, social, and athletic interests. Conversely, schools can also be a source of interpersonal and academic difficulties that become sources of daily stress. Evidence has

pointed to the potential of school experiences to act as both a source of support and a source of stress. Positive aspects of school environment such as school connectedness, school involvement, and positive peer relations were found to be protective against a number of adverse mental health and behavioral outcomes, including emotional distress, suicidality, delinquency, and health-risk behaviors (Resnick et al. 1997; Anderman et al. 1995; Bond et al. 2007; McNeely & Falci 2004). While no studies have investigated whether positive school environments affect underlying physiological processes, social ties and support (or lack thereof) has been shown to influence risk of chronic inflammation and mortality in adulthood (Davis & Swan 1999; Loucks et al. 2006; Heffner et al. 2011; Yang et al. 2013). An investigation into perceived school connectedness and physiological functioning will determine whether this relation is apparent earlier in the life course with a specific focus on adolescent schooling. Meanwhile, adolescent exposure to academic stress, interpersonal strain with peers, or peer rejection increases risk for poorer mental and physical health (Roeser et al. 1998; Torsheim & Wold 2001; Stroud et al. 2009; Caldwell et al. 2004; Prinstein & Aikins 2004). Furthermore, studies focusing exclusively on subjective appraisals of adolescent interpersonal stress and inflammation found elevations of several inflammatory markers months after adolescent reports, including nuclear factor κB (NF-κB) and interleukin-6 (IL-6) (Miller, Rohleder, & Cole 2002), and CRP (Fuligni et al. 2009).

These studies demonstrate the immediate or short-term effects of adolescent social experiences on health and well-being. Returning to the longitudinal emphasis of life course epidemiology, adolescent experiences of stress and support in secondary school may influence pathways of resource attainment, achievements, and future exposures to stress, thus having a long-term impact on health. Central to the stress process framework is the notion that early-life stressors increase the likelihood that individuals will be exposed to further stressors or hardship

based on prior exposures, while access to resources that minimize the impact of these stressors (i.e., social support) will allow individuals to transition out of these pathways (O'Rand 2009). Therefore, stress or stress-buffering events in adolescence may not only influence immediate psychological and physiological states, but also influence later well-being through pathways of disadvantage or advantage that have a cumulative effect on individual health across time. This conceptualization incorporates a life course perspective into the stress process framework by emphasizing the role of early stressors and the availability of support resources in producing later inequalities to stress exposure and stress coping. Based on this longitudinal perspective, I form two additional hypotheses:

> Hypothesis 2a: Higher perceived school connectedness and greater participation in extracurricular activities during secondary school will be associated with lower risk of elevated CRP in young adulthood.

> Hypothesis 2b: Higher perceived academic and social problems in school will be associated with significantly higher risk of elevated CRP in young adulthood.

Collectively, these hypotheses propose that students with positive academic and social experiences in school are more protected against adverse physiological outcomes because of the cognitive and social capital that they gain in adolescence, while adolescents with negative school experiences have increased risk of poor physiological functioning in adulthood because they did not make the same cognitive and social gains. But the relation between school experiences and CRP could also operate through several confounding social and behavioral processes that I

address in my research: 1) family background characteristics that select individuals into particular school experiences and health outcomes; 2) engagement in health risk behaviors; and 3) educational attainment by young adulthood.

First, an observed relation between school experiences and later health may be due to individual selection into particular school experiences through family background characteristics that also influence health outcomes. For example, a student who is higher achieving or more connected to school is more likely to come from a family with greater parent educational attainment, higher family income, and greater parent investment in their child's school success. Since these same family background characteristics also have the potential to influence health across the transition to adulthood, I include several indicators of family background in my analysis that best account for individual selection into particular school experiences and health outcomes. These include family income, parent educational attainment, family structure, and whether parents primarily chose to live in their community because of the school system.

Health status and behaviors also potentially underlie the link between school experiences to inflammation. Body mass index, cigarette smoking, and physical activity, are known to influence inflammation status (Dietrich et al. 2007; O'Loughlin 2008; Park et al. 2005). Engagement in health risk behaviors is also highly correlated with self-efficacy, perceived stress, and particular stress-coping styles in both adolescence and adulthood, making health behaviors a potential behavioral pathway that links adolescent social and cognitive development to physiological outcomes (Naquin & Gilbert 1996; Stewart et al. 1996; Sussman et al. 1993). Educational attainment in young adulthood could also explain the relation between school experiences and CRP. Educational attainment is thought to function as a mediator rather than a confounder, since attenuation of the effect of school experiences after adjusting for later

education would suggest that the benefits of adolescent schooling primarily operate through future educational and economic opportunity.

The Moderating Role of School Context in Adolescent School Experiences and Health

Central to the life course perspective is the notion that individual experiences hinge upon the interaction of individuals with their surrounding contexts (Elder et al. 2003). Adolescent academic and social experiences in school rely upon the opportunities and limitations afforded by the school environment. Therefore, a comprehensive assessment of adolescent schooling must consider the role of school contextual factors in affecting individual experiences and trajectories.

Research has demonstrated the importance of school characteristics and composition on a number of behavioral, academic, and psychological outcomes (Anderman et al. 1995; Choi et al. 2008; McNeely et al. 2002), but little attention has been given to the role of school context in affecting later physical health. Incorporation of school context in the assessment of schooling and physiological health outcomes expands upon the individual-level focus of the life course epidemiology framework. While context is considered in life course epidemiological approaches, it is often conceptualized in terms of one-sided "exposures" to certain experiences, risks, and resources rather than an interaction of individual choices, expectations, and behaviors with the capacity of the environment to accommodate these individual attributes. Meanwhile, ecological frameworks of child and adolescent development propose that nested intrapersonal, interpersonal, and contextual factors interact to influence individual trajectories, thus providing a more complex conceptualization of how context affects individual development (Bronfenbrenner 1977).

Examination of the moderating effect of school contextual factors on the relation between adolescent schooling and health uniquely merges ecological understandings of development with the longitudinal and biosocial emphasis of life course epidemiology. The influence of individual school experiences on later health is unlikely to be the same across socioeconomic contexts. Compared to more advantaged school contexts, adolescent academic and social success in disadvantaged schools is more difficult to achieve but may also provide greater individual benefit. Recent studies that have tested the moderating role of school context on the linkages between adolescent experiences and individual well-being found that better individual resources (such as peer support and social participation) had a more profound positive effect on the achievement and psychological outcomes of adolescents from environments of disadvantage (Crosnoe et al. 2003; Hull et al. 2008; Jessor et al. 1998). These findings suggest that positive individual experiences are more crucial in contexts of adversity because they protect individuals against the heightened risk for negative outcomes.

School socioeconomic composition may be especially important for health outcomes. School-level aggregates of student socioeconomic indicators reflect the available resources and overall quality of the school environment, and these contextual factors are likely to have a profound influence on the academic engagement and social adjustment of adolescents. Indeed, prior research identifies significant differences in achievement and psychological well-being based on socioeconomic context, with students from disadvantaged schools more likely to be low achieving and exhibit poorer mental health (Lee & Burkam 2002; Caldas & Bankston 1997; Pong 1998). Adolescent school experiences may also differentially affect later physical health and well-being across socioeconomic contexts. Positive school experiences have to potential to protect against contextual adversity by providing opportunities for upward mobility as

adolescents transition into adulthood. Despite the increased risk for negative individual outcomes in contexts of school disadvantage, higher achieving and more socially and academically adjusted adolescents are more likely to gain better status attainment and therefore enjoy improved overall health in adulthood compared to those in disadvantaged contexts who do not have these same positive experiences. My final hypothesis is based on this multilevel perspective:

> *Hypothesis 4:* Positive school experiences at the individual level, as measured by high academic achievement and aptitude, greater school connectedness, fewer school problems, and higher extracurricular participation, will be most protective against young adult inflammation in contexts of higher school disadvantage.

Inflammation Burden as an Indicator of Young Adult Health

To observe the relation between adolescent school experiences, school disadvantage, and young adult physiological functioning, I use C-reactive protein as an indicator of inflammation burden. Inflammation is thought to be a significant biological mechanism that lies at the interface of a number of social conditions and the emergence of chronic disease across the life course. Evidence across epidemiology, psychology, and sociology implicate several interrelated social, psychological, and behavioral factors in contributing to inflammation burden, including psychosocial stress (Black & Garbutt 2002), social integration and support (Loucks et al. 2006), depression (Copeland et al. 2012), and socioeconomic status (Jousilahti et al. 2003). In contrast to the acute spike in inflammatory markers that is observed in the healthy immune response to a pathogen or injury, most biosocial research focuses on the presence of low-grade inflammation

with no pathogenic target, which has the potential to damage healthy tissues. Persistent low-grade inflammation has been shown to increase the risk of age-related chronic illness such as cardiovascular disease, autoimmune disorders, and cognitive decline (Flier 1998; Alley et al. 2008; Hwang et al. 1997). The biological processes that underlie the link between adverse social or psychological conditions and inflammation have not been fully identified, but neuropsychological research finds evidence that prolonged exposure to stressful or adverse conditions acts on the regulatory balance between neurological stress mediators and immune function (Miller, Rohleder, & Cole 2002).

The relation between adolescent schooling and inflammatory functioning has not been investigated in prior research. Studies assessing the relation between education and inflammation exclusively focus on educational attainment as a predictor of later inflammation burden, and found that greater educational attainment is predictive of lower CRP and interleukin-6 (Loucks et al. 2006; Ranjit et al 2007). While these studies provide important evidence for the positive relation between education and lower inflammation burden, use of educational attainment as the only educational indicator misses the aspects of schooling that more directly measure cognitive and stress-coping skills that may influence physiological functioning. These studies also do not consider the importance of the timing of educational experiences and subsequent health outcomes. Since adolescence is conceptualized as a sensitive period for social and cognitive development in life course epidemiological research, later physiological functioning may be particularly sensitive to school experiences that occur during adolescence. Further, these studies do not consider the role of contextual factors in affecting educational experiences and health outcomes. Finally, prior studies focus on biological outcomes in middle- to old-age samples. Disparities in young adult physiological functioning would provide evidence that the late-life

chronic illnesses associated with educational experiences may begin to emerge "under the skin" much earlier in the life course and long before the emergence of illness symptomology.

In drawing together these social, psychological, and epidemiological frameworks, my research takes a multilevel and longitudinal approach to elucidate the relation between domains of adolescent school experience, school socioeconomic context, and a widely-used physiological indicator of health. Identifying the adolescent predictors of young adult physiological functioning draws attention to the early-life individual and contextual factors that influence life course trajectories in health, thus having important implications for future research and policies that are centered around education-based health disparities and the potential for intervention programs within U.S. secondary schools.

DATA AND METHODS

Data source:

I used data from the National Longitudinal Study of Adolescent Health, which is a nationally representative, school-based sample of 20,745 adolescents that were first interviewed in grades 7-12 during the 1994-95 academic year. The sampling frame for Add Health included all high schools in the United States, and a total of 80 high schools were randomly selected to participate in the survey, with an additional 52 feeder middle schools attached to the sample of high schools. A sample of adolescents was randomly selected from a count of students that participated in the in-school questionnaire combined with student rosters provided by the schools, and this sample participated in a more detailed, in-home interview. Data for the in-home interview were collected through computer-assisted personal interviews for all waves of the study. Respondents were followed for four survey waves, with the most recent survey conducted in 2008.

My analysis used data from Waves I and IV. Wave I data collection took place both in-school and in-home, with questionnaires administered to adolescents, parents, and school administrators. Adolescent in-school questionnaires were completed on paper by over 90,000 students who attended the selected schools during a 45- to 60- minute class period, and 20,745 adolescents were selected from school rosters and the in-school survey to complete the in-home interview. Adolescent and parent in-home questionnaires were conducted through a combination of computer-assisted personal interviews (CAPI) and computer-assisted self-interviews (CASI), depending on the sensitivity of the interview topic. Wave I administrator questionnaires were

self-administered and items covered school policies, teacher characteristics, health services, and student body characteristics.

Wave IV data collection took place in 2008, when respondents were from the ages of 24 to 32. Of the eligible study participants, 80.3% were interviewed in Wave IV, leaving a sample of 15,701 participants that were included in both Waves I and IV. Data in Wave IV was collected through a 90 minute in-home CAPI/CASI interview followed by physical measurements and biospecimen collection. Biological specimens included the collection of saliva samples and dried blood spots, which were used for measurement of cardiovascular, metabolic, and immunologic functioning, including high-sensitivity C-reactive protein (hs-CRP). Blood spots were mailed to the University of Washington Medical Center Immunology Lab in Seattle, WA for CRP assays.

To capture school contextual disadvantage, school-level measures of academic, social, and socioeconomic background of students were calculated from a sample of 71,004 individuals that participated in the in-school survey and had complete data for the variables of interest. Using a larger sample size to capture school-level moderators ensures that contextual measures more accurately reflect the student body within each school. Schools with less than 35% of overall student participation in the in-school survey were dropped from analysis because school-level aggregates of socioeconomic disadvantage calculated from a small portion of students would not be representative of the entire school population. Elimination of schools with low participation left 126 of the original 144 schools for analysis.

The final analytic sample in this study was limited to 5,611 respondents who participated in both Waves I and IV of Add Health and had complete data for all variables included in this analysis. There are several reasons for the significant loss of the original sample size. First,

approximately 25 percent of adolescents at Wave I are missing in-school data used to obtain school experiences, either because they were absent from school on the day the survey was administered or because the in-school questionnaire was not administered in their school[1]. Students from schools that had a survey participation rate of <35% were also eliminated from analysis. Furthermore, nearly 20 percent of the sample was excluded from analysis due to either missing CRP data or CRP values that were out of the assay range. Finally, respondents who did not have corresponding parent interviews (15%) were also eliminated from analysis due to missing data on parent educational attainment and household income. Sampling weights were applied to all analyses to adjust for clustered sampling design, attrition across study waves, and overall sample composition.

Dependent Variable:

High-sensitivity C-reactive protein (hs-CRP) was collected and measured from blood spots in Wave IV as an indicator of chronic inflammation. An ordinal measure of CRP was constructed based on clinical cutoff points that are used to gauge risk of cardiovascular disease: < 1.0 mg/L is a healthy CRP range; 1.0 - 3.0 mg/L indicates moderate-risk inflammation; 3.0 - 10.0 mg/L indicates high-risk inflammation, and 10.0 - 40.0 mg/L indicates the highest risk category. Most studies investigating the effects of social conditions on inflammation drop individuals from analysis that have CRP greater than 10.0 mg/L, because CRP values above this cutoff were thought to be due to acute infection or injury. However, these cutoffs were created based on older cohorts, and a significantly greater portion of the Add Health sample (10.2%) had a CRP value greater than 10 mg/mL compared to older cohorts in nationally representative

[1] Several schools did not consent to in-school survey administration but did provide school rosters for in-home interviews.

samples (Rifai & Ridker 2003; Shankar et al. 2007). These cohort increases are unlikely to be due to population increases in infection occurrence, but rather reflect cohort increases in chronic inflammation due to a higher prevalence of obesity (Reither, Hauser, & Yang 2011). For this reason, CRP values between 10.0 and 40.0 mg/L were included in the present analysis. To account for elevations in CRP that may have instead been indicative of acute inflammatory response, individuals that reported more than one recent infection or more than one subclinical symptom of infection within four weeks prior to the day of interview were dropped from analysis.

Independent Variables:

a) Individual-level covariates:

Five indicators of school experiences at Wave I were used in this analysis. Academic achievement was measured through student reports of grade point average (GPA) in the in-school survey. Students reported grades for English, mathematics, science, and social studies granted that they were currently taking these courses, and GPA was calculated by averaging the grades that students reported. Values range from 1 to 4, with higher values reflecting higher grades. Academic aptitude was measured through scores on the Add Health Picture Vocabulary Test (AHPVT) that was administered during the in-home survey. The AHPVT is an abridged version of the Peabody Picture Vocabulary Test, which estimates verbal ability and has been used as a proxy of scholastic aptitude (Halpern et al. 2000; Harris et al. 2002). AHPVT scores range from 13 to 146 and were assessed in quartiles. The school connectedness scale was constructed from three items in the Wave I in-school survey: respondents were asked how much they feel "close to people at this school," "a part of this school," and "happy at this school."

Response categories range from (1) strongly agree to (5) strongly disagree, and were reverse coded for analysis so that higher scores reflect higher connectedness. School problems were captured through a single scale that is indicative of social and academic strain within the classroom. School problems is the sum of four survey items that ask how often respondents had trouble "getting along with teachers" and "getting along with students," "paying attention in school" and "getting homework done," with response categories ranging from (0) never (1) just a few times (2) about once a week (3) almost everyday (4) everyday. Participation in school extracurricular activities were reported by adolescents in the Wave I in-school survey. The survey included a list of 33 activities. Activities were separated into sport or academically-oriented activities for analysis, with categories of no participation, 1-2 activities, and 3 or more activities. See Appendix A for a more details on school experience measures and a complete list of extracurricular activities.

b) School-level disadvantage:

Parent educational attainment and the proportion of single parent households at the school level were used as indicators of school socioeconomic disadvantage. Schools with a mean parent educational attainment of high school or less and a proportion of single parent households greater than 33% (cutoff determined by the highest quartile) were classified as high disadvantage. Schools with only one or neither disadvantage indicator were classified as lower disadvantage. While there is greater variation in contextual disadvantage across schools than can be captured in a binary measure, my measurement of school disadvantage allows for the identification of schools that are at the highest level of disadvantage based on the indicators available for the maximum number of individuals in the data.

c) Additional controls

Additional controls were included to adjust for selection into particular school environments and to explore potential behavioral and social pathways that link school experiences to later inflammation. Family income at Wave I, parent educational attainment, family structure, and whether parents primarily chose to live in their community because of the school system were incorporated to adjust for earlier life circumstances that potentially select students into particular school environments and experiences. In addition, immigrant status of the adolescent was added to adjust for potential differences in Picture Vocabulary Test scores due to English language proficiency. Health status and behaviors in Wave IV were also adjusted to account for potential confounders in the relation between school experiences and CRP, including cigarette smoking, anti-inflammatory medication use, body mass index (BMI), physical activity, and use of hormonal contraceptives. Wave IV educational attainment was controlled for as a proxy of future achievement and socioeconomic standing. Educational attainment was measured using a five category indicator of highest level of education: 1) "High school or less," 2) "Vocational training," 3) "Some college," 4) "College graduate," and 5) "More than college."

Methods:

Ordinal logistic regression analysis was used to determine the association between school experiences at Wave I (academic achievement, academic aptitude, school connectedness, school problems, and extracurricular participation) and CRP at Wave IV. Initial models adjusted for age, sex, and race/ethnicity, and fully-adjusted models added family background characteristics

(i.e., family income at Wave I, parent educational attainment, family structure, whether the adolescent was born in the U.S., and whether the parent chose to live in their community because of the schools), health status and behaviors (i.e., body mass index, cigarette smoking, medication use, physical activity, and hormonal contraceptive use), and educational attainment at Wave IV. Additional analyses using generalized ordered logit models (Williams 2006) showed that the ordinal operationalization of CRP did not violate the proportional odds assumption (i.e., the assumption that the relationship between each pair of CRP outcome groups is the same; results not shown). Interaction terms between each of the individual-level school experiences and the school disadvantage scale were incorporated into the final ordinal logistic model to determine the moderating effect of disadvantaged school context on school experiences and young adult CRP. Wald tests were performed to test the significance of the interactions. Ordinal logistic regression analyses were also performed on samples stratified by school disadvantage to guide the interpretation of interaction effects. Analyses were completed using Stata 12.0.

RESULTS

Descriptive analysis

Table 1 shows weighted descriptive statistics for the full sample. Participants had a mean CRP of 3.87 mg/L with a standard deviation of 5.73. For GPA, the full sample had a mean of 2.88, meaning that the average GPA reported by students was nearly a B. The mean AHPVT score was 103.76 for the full sample, which is relatively high considering that the scores range from 14 to 138. The mean perceived school connectedness for the entire sample was 3.59 with a possible range of 1 to 5, indicating that adolescents tended to report slightly more positive perceptions of connectedness. School problems had a mean of 1.57 for the full sample (range 0 to 4). The majority of adolescents reported participating in 1-2 extracurricular sports-related activities (44.35%), though many also reported no participation (38.60%), and few reported participation in 3 or more sports activities (17.06%). A similar pattern is seen in adolescent participation in more academically-oriented extracurricular activities, with 42.92% reporting participation in 1-2 activities, 41.67% reporting no participation, and 15.40% reporting participation in 3 or more activities.

Stratification of the sample by low and high school-level socioeconomic disadvantage reveals that these subsamples differ significantly on most key predictors and controls. On average, individuals in highly disadvantaged school contexts had significantly higher CRP (p=0.001), lower GPA (p<0.001), lower AHPVT scores (p<0.001), lower school connectedness

(p=0.007), higher school problems (p=0.019), and lower participation in academically-oriented extracurricular activities (p=0.038). Those in high disadvantage also had lower family income on average (p<0.001), lower parent educational attainment (p<0.001), lower likelihood of living with two biological parents in adolescence (p<0.001), higher BMI (p<0.001) and less physical activity in young adulthood (p=0.036), and were also more likely to be Black or Hispanic (p=0.006).

There are also significant differences between the analytic sample and those respondents who were omitted due to missing data. Chi square tests show that the analytic sample had significantly higher AHPVT scores, higher family income, and higher parent educational attainment compared to those who did not complete the in-school survey (results not shown). Given that analysis was done on a sample with higher cognitive ability and higher socioeconomic status, results are expected to produce more conservative estimates than would be found in the full initial sample.

Table 2 shows the descriptive statistics for indicators of school-level socioeconomic characteristics. Parent educational attainment and the proportion of single parent households were obtained by aggregating student responses from the in-school survey within each school. Nearly 34% of schools had a median parent educational attainment of high school or less, and the mean proportion of single parent households across schools was 0.28, indicating that a substantial portion of participants were exposed to socioeconomic disadvantage during adolescence. The school disadvantage scale was constructed by combining measures of parent educational attainment and single parent households. Among schools, 16% were in the highest disadvantage category, meaning that the median parent educational attainment was high school

or less *and* the number of single parent households among those surveyed within the school was greater than 33%.

Regression analysis

Table 3 shows ordinal logistic regression results for the effect of adolescent school experiences on young adult CRP, as well as the cross-level interactions between individual school experiences and school socioeconomic disadvantage. After adjusting for age, sex, and race in Model I, grade point average (GPA), Picture Vocabulary Test (AHPVT) scores, and participation in extracurricular activities were all protective against elevated CRP in young adulthood. In fact, highest achieving students (those with an A average) had 31% lower odds of moving up one category of CRP compared to the lowest achieving students (OR: 0.69; CI 0.52-0.93), and students with a B average had 17% lower odds of elevated CRP (OR: 0.83; CI 0.67-1.0). Model I also shows that individuals who tested above the bottom quartile of the AHPVT were significantly less likely to have elevated CRP, with those in the top quartile of the AHPVT having the lowest odds of elevated CRP levels relative to those that scored in the bottom quartile (OR: 0.68; CI 0.55-0.83). Interestingly, school connectedness and school problems had no association with young adult CRP. Finally, participation in 1-2 academically-oriented extracurricular activities was significantly protective against elevated CRP (OR: 0.83; CI 0.72-0.97), while only a modest effect was observed for participation in 1-2 sports-related activities (OR: 0.88; CI 0.76-1.0), and no effect was observed for participation in three or more sport or academic clubs (OR 0.84, CI 0.67-1.1; OR 0.92, CI 0.75-1.13, respectively).

Models II-IV of Table 3 show the associations between school experiences and CRP after independently adjusting for family background characteristics, educational attainment in young

adulthood, and health status and behaviors in young adulthood. Model II shows that family background characteristics partially reduced the effect of GPA on CRP (OR: 0.77; CI 0.57-1.0 for highest achieving students compared to lowest achieving). Adjustment for educational attainment and health behaviors in Models III and IV, and simultaneously adjusting for all covariates in Model V completely attenuated the effect of high academic achievement on CRP (p=0.61), suggesting that more advantaged family background, better health behaviors, and future educational attainment explain the protective effect of adolescent academic achievement on adult CRP. Models II-V also show that scoring in the highest AHPVT quartile and participation in 1-2 academic extracurricular activities both continued to be protective against elevated CRP even after adjusting for family background, health behaviors, and educational attainment (OR 0.71, CI 0.56-0.89; and OR 0.84, CI 0.72-0.98 in fully-adjusted model, respectively).

Model VI incorporates cross-level interactions for individual school experiences and school-level socioeconomic disadvantage. A significant interaction term was observed for GPA and school disadvantage, such that adolescents in contexts of high socioeconomic disadvantage experienced greater benefits of high GPA on young adult CRP compared to adolescents in contexts of lower disadvantage. In fact, supplemental analysis shows that GPA had no significant effect on CRP levels for individuals from contexts of lower socioeconomic disadvantage, while being a high achiever in a school context of high disadvantage significantly decreased the odds of having elevated CRP[2]. The moderating effect of school disadvantage on the link between GPA and CRP is illustrated in Figure 1. While low GPA appeared to increase the predicted

[2] Ordinal logistic regression models stratified by school-level disadvantage show that high academic achievement in contexts of lower disadvantage had no effect on CRP (OR: 1.06, CI: 0.75-1.51 for students with an A average), while high academic achievement in disadvantaged schools decreased the odds of elevated CRP by 61% (CI: 0.21-0.73).

probability of having elevated CRP for those in high disadvantage, high GPA also had a greater protective effect on elevated CRP for students in high disadvantage. School disadvantage also had a moderating effect on the association between school connectedness and CRP. Model VI shows a significant interaction term between school connectedness and high disadvantage (OR: 0.82; CI 0.67-1.0), meaning that higher school connectedness significantly decreased the odds of elevated CRP for those in contexts of high disadvantage relative to those in lower disadvantage. However, stratification by school disadvantage reveals that the main effect of school connectedness was not significant for those in low *or* high disadvantage, meaning that the significance of the interaction between school connectedness and high disadvantage does not necessarily reveal a protective effect of school connectedness in disadvantaged contexts, but instead reflects a difference in the directionality of the effect of school connectedness on CRP across low and high disadvantage groups[3]. The interaction between school connectedness and high disadvantage is illustrated in Figure 2. Wald tests confirmed the significant interactions between GPA and CRP and school connectedness and CRP (not shown).

[3] Ordinal logistic regression models stratified by school-level disadvantage show no significant main effect of school connectedness in contexts of low disadvantage (OR: 1.07; CI, 0.98-1.2) or high disadvantage (OR: 0.91; CI, 0.78-1.1).

DISCUSSION

This investigation is the first to identify several domains of adolescent experiences within school as significant predictors of young adult physiological functioning. Assessment of both academic and social factors in adolescence allows for a more nuanced investigation of the particular school experiences that forecast later health. Further, the use of C-reactive protein as a measurement of health status provides unique insight into the underlying physiological processes that may link adolescent experiences to later chronic illness. Educational research traditionally uses health measures that are subjective (i.e., self-rated health) or only measured in late adulthood (i.e., chronic conditions and mortality), thus limiting our understanding of the role that early educational experiences have on more subtle pathways of health risk across the life course. Finally, identifying the moderating role of school socioeconomic disadvantage highlights that individual school experiences are framed within the opportunities or limitations afforded by the surrounding environment.

My analysis has two primary findings that contribute to the current literature. First, only particular school experiences in adolescence were predictive of later physiological functioning. I find support for the hypothesis that cognitive capital as assessed by grade point average (GPA) and Add Health Picture Vocabulary Test (AHPVT) scores is protective against clinically elevated CRP in young adulthood (Hypothesis 1). Participation in academically-oriented extracurricular activities also lowered the odds of elevated CRP in young adulthood (Hypothesis 2a). Second, school context was a significant moderator of several of these associations. Models

incorporating the moderating effect of school socioeconomic disadvantage reveal that academic achievement and school connectedness were protective against elevated CRP for individuals from schools of high socioeconomic disadvantage relative to those from schools of low disadvantage, providing support for Hypothesis 4a and refuting Hypothesis 4b.

These results have important implications for the longitudinal pathways between adolescent school experiences and young adult health. Findings that academically-oriented components of school experience (i.e., academic achievement, cognitive aptitude, and participation in academic extracurricular activities) were significantly associated with inflammation status approximately fifteen years later suggest that these objective academic factors are particularly important for social, economic, and behavioral pathways to future health, while indicators of more subjective social and academic experience do not have the same longitudinal predictive power. Previous research finds evidence for the protective effect of high school academic achievement on future health (Herd 2010), but does not assess other domains of school experience. Interestingly, cognitive aptitude and participation in academic extracurricular activities had stronger associations with young adult CRP than grade point average after adjusting for all confounders, suggesting that aspects of academic standing that are rarely considered may be the most important for understanding the education-health relationship. Participation in academically-oriented extracurricular activities may reflect adolescent school involvement that provides additional social and educational exposures, therefore promoting individual self-efficacy and academic interest. The number of extracurricular activities also appears to be important, such that participation in 1-2 activities was more beneficial than participation in three or more. More focused participation in a couple of activities rather than taking part in many might allow for a better balance of school and social activities, or may be

reflective of better time management skills. Additional analysis also demonstrated that the protective effect of academic extracurricular activities did not depend of the type of activity (not shown), suggesting that participation in any academic group is beneficial. The significant protective effect of cognitive aptitude on future CRP has important implications for the pathways linking adolescent schooling to inflammation. Cognitive aptitude as assessed by the AHPVT is not truly a "school experience," but likely reflects the cognitive abilities and problem-solving skills, developed through a combination of individual propensities and academic experiences, that contribute to decision making and stress management across the transition to adulthood. Therefore, extracurricular participation and cognitive aptitude may be related to young adult CRP through the lasting role that these factors have on self-concept, stress coping, and psychological well-being.

Supplemental analyses using a constructed school experience scale also showed that excelling in any of the three academic factors (academic achievement, cognitive aptitude, or involvement in academic extracurricular activities) reduced the odds of elevated CRP by 21%, while those that had a positive standing in all three had 30% lower odds of high CRP by young adulthood[4]. These results suggest that while each domain of academic experience is an important independent predictor of future health, having positive outcomes in any one of them is significantly protective against future inflammation, and having all three is the most beneficial.

[4] A school experience scale was constructed by summing binary indicators of high academic achievement (GPA of A-B), high cognitive aptitude (4th quartile of AHPVT), and any academic extracurricular participation. Model adjusts for all indicators of family background, health behavior, and educational attainment that were used for the fully adjusted model in Table 3.

School connectedness and school problems were unrelated to young adult CRP. While greater school connectedness and fewer school problems have been found to be beneficial for a number of adolescent outcomes (Resnick et al. 1997; Anderman et al. 1995; Bond et al. 2007; McNeely & Falci 2004), this is the first study to test whether the benefits of subjective appraisals of school experiences carry into young adult health. It is possible that perceptions of connectedness and problems in school have a more contemporaneous effect on adolescent well-being through stress process and stress-buffering mechanisms, but that these mechanisms do not have an enduring influence on social adjustment or stress coping as individuals enter adulthood. School connectedness and problems might be highly variable across adolescence, or might not constitute the chronic stress or long-term stress-buffering that leads to further exposure to stressors or support. Further study should assess whether adolescent perceptions of school connectedness and school problems at multiple points in time would more effectively capture stress and stress-buffering pathways.

Probably the most intriguing result is the moderating effect of school socioeconomic disadvantage on the link between school experiences and CRP. Findings indicate that high academic achievement and school connectedness were more protective against future elevation in CRP for individuals from schools characterized by high socioeconomic disadvantage relative to those in low disadvantage. Why was GPA so predictive of future CRP for adolescents in disadvantaged contexts, but not for those in areas of lower disadvantage? One interpretation is that school achievement allows for greater mobility out of disadvantaged contexts as individuals transition into adulthood, but has little effect on the social and economic mobility of those that are already in contexts of lower disadvantage. In other words, adolescent academic achievement might be the most influential to future health in contexts where doing well in school matters

more for future status attainment, while academic achievement does little to affect health in contexts where individuals are more likely to have social and economic supports to fall back on if they do not succeed in school.

The strong association between high academic achievement and CRP in disadvantaged contexts might also be due to broader pathways of adolescent resilience. It is important to note that while high academic achievement was strongly associated with lower odds of elevated CRP in school contexts of high disadvantage, there were relatively few high achieving adolescents from highly disadvantaged contexts in the sample (n=60). Still, the strength of this protective effect suggests that there is something exceptional about these high-achieving individuals that enables them to succeed academically in spite of contextual adversity. Academic achievement in contextual disadvantage may be capturing more stable internal characteristics (such as conscientiousness or motivation) or external sources of support (such as parent involvement in academics or support from teachers) that promote resilience in at-risk adolescents and enable successful transition into adulthood (Smokowski et al. 1999; Olsson et al. 2003). These internal characteristics and external supports might also influence stress-coping, health behaviors, and therefore overall health across the transition to adulthood. While it is difficult to disentangle the pathways underlying the links between school experiences, contextual disadvantage, and later health, identification of this significant moderating effect paves the way for future analysis to identify the individual characteristics and resources that promote adolescent success in disadvantaged contexts, thus affecting future health.

While the significant interaction between school connectedness and school disadvantage suggests a stronger protective effect of school connectedness on later CRP in contexts of high disadvantage, these results should be interpreted with caution. Additional analysis found no main

effect of school connectedness on either level of disadvantage, but instead showed a slight though insignificant positive relationship between school connectedness and CRP in low disadvantage, and a slight and insignificant negative relationship between school connectedness and CRP in contexts of high disadvantage (see Figure 2). Although not significant, the positive relationship between school connectedness and CRP in low disadvantage was not expected. Future analysis should determine whether school connectedness has a non-linear relation with CRP, such that the benefits of school connectedness on health are only observed among the most connected adolescents.

There are several limitations in the current study that should be addressed in future research. First, while this study is longitudinal such that data on school experiences were collected years prior to measurement of CRP, school experiences were only measured at one time point in adolescence, and CRP was only assayed at one time point in young adulthood. Repeated measures of school experiences and physiological indicators would allow for stronger causal inferences in the relation between schooling and CRP, but there is currently no nationally representative data that would allow for this type of analysis across the transition to adulthood. Further, I only use one physiological indicator of health. C-reactive protein has been shown to predict a number of adverse health outcomes with age (Pearson et al. 2003, Barzilay et al. 2001, Ridker et al. 1998, Kravitz et al. 2009), but it is important to remember that CRP is an indicator of the inflammatory response, which is only one aspect of individual health (albeit an important one). Finally, further research is needed to determine whether those that are academically successful in adolescence grow up to be healthy adults because of steady personality traits or important social resources that affect status attainment, health behaviors, and psychological well-being across the transition to adulthood.

Identification of health disparities based on school experiences and contexts important implications for future research and policy initiatives. Intervention programs have greater opportunities to target the school environment over other adolescent contexts, such as the family and peer groups outside of the classroom. While finding ways to improve student achievement and promote the development of cognitive skills is already a fundamental goal of educational research and policy, evidence of the potential health benefits of these educational experiences provides even further justification that schools should be the focus of policy aimed to improve individual well-being across the life course.

Table 1. Descriptive Statistics for Individual-Level Variables, Mean (SD) (N=5,611)

	Full Sample	Low Disadvantage	High Disadvantage	p-value[a]
Key variables				
C-Reactive Protein (CRP; mg/L)	3.87 (5.73)	3.72 (5.53)	4.69 (6.73)	0.001
<1.0 mg/L (%)	33.56	34.39	29.08	
1.0-3.0 mg/L	29.76	30.56	28.71	
>3.0-10.0 mg/L	26.5	25.73	29.09	
>10.0-40.0 mg/L	10.18	9.32	13.12	
Grade Point Average (GPA)	2.88 (0.83)	2.92 (0.81)	2.64 (0.92)	<0.001
A (%)	11.25	10.57	17.70	
B	43.58	32.45	39.23	
C	33.5	44.95	36.06	
D	11.67	12.03	7.01	
Picture Vocabulary Test (AHPVT)	103.76 (13.97)	104.91 (13.46)	97.46 (14.46)	<0.001
School Connectedness	3.59 (1.05)	3.62 (1.04)	3.46 (1.09)	0.007
School Problems	1.57 (1.18)	1.53 (1.15)	1.77 (1.33)	0.019
School Sports Participation	1.28 (1.60)	1.30 (1.62)	1.12 (1.48)	
0 (%)	38.6	38.03	41.66	
1-2	44.35	44.42	43.94	0.411
3+	17.06	17.54	14.40	
School Academic Clubs Participation	1.23 (1.86)	1.28 (1.87)	1.14 (1.85)	
0 (%)	41.67	40.59	47.57	
1-2	42.92	44.24	35.75	0.038
3+	15.40	15.17	16.68	
Demographic characteristics				
Female (%)	48.76	51.47	50.00	0.501
Age (Wave IV)	28.19 (1.84)	28.19 (1.82)	28.16 (1.93)	0.919
Race (%)				
White	73.24	77.39	50.59	
Black	12.57	9.42	29.82	0.006
Hispanic	7.92	6.90	13.53	
Other	6.26	6.30	6.06	
Family background				
Family Income (Wave I; thousands)	47.55 (53.74)	50.79 (56.53)	29.95 (26.64)	<0.001
Refused (%)	8.84	9.07	7.64	
Missing	1.52	1.37	2.36	
Family Structure (Wave I; %)				
Two biological parents	58.94	61.44	45.33	
One biological, one step parent	17.95	18.13	16.99	<0.001
Other	23.1	20.43	37.68	

Parent Educational Attainment (Wave I; %)				
High school or less	35.33	31.06	58.66	
Vocational training	11.04	11.72	7.35	<0.001
Some college	19.92	20.22	18.30	
College graduate	18.74	20.22	10.63	
More than college	14.97	16.79	5.08	
Born in U.S.	96.19	96.68	93.54	0.194
Parent chose neighborhood for schools (%)	12.60	13.36	8.47	0.046
Respondent education				
Educational Attainment (Wave IV; %)				
High school or less	20.94	18.37	34.96	
Vocational training	9.06	8.58	11.65	
Some college	34.63	34.65	34.49	<0.001
College graduate	22.53	24.54	11.53	
More than college	12.85	13.85	7.37	
Health status & behaviors				
Body mass index (Wave IV)	29.08 (7.91)	28.82 (7.74)	30.53 (8.68)	<0.001
Current smoker (Wave IV; %)	24.64	23.86	28.92	0.216
Physical activity (Wave IV)	6.52 (6.11)	6.58 (6.09)	6.23 (6.19)	
None (%)	12.54	11.94	15.79	
1-3 times a week	24.18	23.97	25.35	0.036
4+ times a week	63.28	64.09	58.87	
Anti-inflammatory medications	28.29	28.20	28.82	0.805
Hormonal contraceptives	20.17	20.76	16.95	0.080

[a]p-values indicate whether descriptive measures differ significantly across disadvantage groups. t-tests were used to compare means across groups for continuous measures; chi square tests compared categorical measures across groups.

Table 2. School-Level Characteristics, Descriptive Statistics (N=126)

Variable	Mean (SD)	Min	Max
Socioeconomic context			
Median parent educational attainment (%)			
High school or less	33.76		
Vocational training	23.84		
Some college	21.98		
College graduate	18.81		
More than college	1.61		
Proportion single parent households	0.28 (.101)	0.03	0.56
School disadvantage scale (%)			
Low to moderate disadvantage	84.20		
High disadvantage	15.80		
School size (%)			
1-400 students	22.67		
401-1000 students	45.35		
1001-4000 students	31.98		
Urbanicity (%)			
Urban	32.56		
Suburban	54.65		
Rural	12.79		

Table 3. Effect of School Experiences on CRP Levels, Moderating Effect of School-Level Disadvantage; Odds Ratios (OR) and 95% Confidence Intervals (CI) (N=5,611)

	Model I	Model II	Model III	Model IV	Model V	Model VI
GPA (ref. D or lower)						
C	0.991	1.019	1.021	0.934	0.957	0.995
	(0.780 - 1.259)	(0.804 - 1.292)	(0.798 - 1.306)	(0.743 - 1.175)	(0.762 - 1.202)	(0.756 - 1.309)
B	0.831*	0.876	0.905	0.883	0.921	0.967
	(0.668 - 1.032)	(0.696 - 1.102)	(0.722 - 1.135)	(0.708 - 1.100)	(0.732 - 1.160)	(0.738 - 1.268)
A	0.694**	0.765*	0.810	0.866	0.921	1.041
	(0.519 - 0.928)	(0.568 - 1.032)	(0.601 - 1.091)	(0.639 - 1.176)	(0.671 - 1.264)	(0.731 - 1.483)
AHPVT (ref. 1st quartile)						
2nd quartile	0.769**	0.792**	0.786**	0.812**	0.828*	0.837
	(0.618 - 0.956)	(0.633 - 0.992)	(0.628 - 0.984)	(0.661 - 0.997)	(0.669 - 1.026)	(0.660 - 1.062)
3rd quartile	0.802**	0.855	0.833*	0.812**	0.836*	0.844
	(0.656 - 0.981)	(0.700 - 1.044)	(0.676 - 1.027)	(0.665 - 0.992)	(0.678 - 1.030)	(0.679 - 1.050)
4th quartile	0.678***	0.757***	0.734***	0.667***	0.706***	0.724***
	(0.553 - 0.831)	(0.613 - 0.934)	(0.594 - 0.908)	(0.544 - 0.819)	(0.561 - 0.889)	(0.569 - 0.922)
School connectedness	1.025	1.030	1.033	1.040	1.040	1.073
	(0.950 - 1.107)	(0.956 - 1.110)	(0.956 - 1.116)	(0.957 - 1.129)	(0.958 - 1.128)	(0.982 - 1.173)
School problems	1.013	1.015	1.002	0.984	0.981	0.994
	(0.950 - 1.080)	(0.953 - 1.081)	(0.940 - 1.068)	(0.922 - 1.052)	(0.918 - 1.048)	(0.924 - 1.069)
School sport clubs (ref. none)						
1-2	0.875*	0.901	0.899	0.907	0.923	0.915
	(0.756 - 1.012)	(0.774 - 1.049)	(0.778 - 1.038)	(0.777 - 1.058)	(0.786 - 1.083)	(0.769 - 1.089)
3+	0.841	0.866	0.868	0.915	0.939	0.919
	(0.670 - 1.057)	(0.694 - 1.081)	(0.690 - 1.092)	(0.724 - 1.157)	(0.743 - 1.188)	(0.707 - 1.195)
School academic clubs (ref. none)						
1-2	0.834**	0.843**	0.854**	0.834**	0.838**	0.807**
	(0.720 - 0.966)	(0.727 - 0.977)	(0.736 - 0.991)	(0.714 - 0.974)	(0.717 - 0.979)	(0.685 - 0.950)
3+	0.922	0.968	0.980	0.996	1.039	0.966
	(0.751 - 1.131)	(0.786 - 1.192)	(0.795 - 1.209)	(0.803 - 1.234)	(0.834 - 1.295)	(0.763 - 1.223)

High school disadvantage	2.498**
	(1.062 - 5.873)
Cross-level interactions	
GPA x High disadvantage	
(ref. D or lower x Low disadvantage)	
C x High disadvantage	0.844
	(0.548 - 1.301)
B x High disadvantage	0.764
	(0.495 - 1.180)
A x High disadvantage	0.327***
	(0.165 - 0.649)
AHPVT x High disadvantage	
(ref. 1st quartile x Low disadvantage)	
2nd quartile x High disadvantage	1.041
	(0.635 - 1.708)
3rd quartile x High disadvantage	1.110
	(0.602 - 2.048)
4th quartile x High disadvantage	0.911
	(0.451 - 1.841)
School connectedness x High disadvantage	0.808**
	(0.662 - 0.986)
School problems x High disadvantage	0.994
	(0.924 - 1.069)
Sport clubs x High disadvantage	
(ref. none x Low disadvantage)	
1-2 x High disadvantage	0.981
	(0.657 - 1.464)
3+ x High disadvantage	1.037
	(0.560 - 1.920)
Academic clubs x High disadvantage	

(ref. none x Low disadvantage)	
1-2 x High disadvantage	1.293
	(0.807 - 2.073)
3+ x High disadvantage	1.576
	(0.866 - 2.870)

*** p<0.01, ** p<0.05, * p<0.1

Note: All models adjust for sex, race/ethnicity, and age. Model II adjusts for wave 1 family income, family structure, parent educational attainment, U.S. born, and whether parents chose to live in their neighborhood because of the schools. Model III adjusts for educational attainment at wave IV. Model IV adjusts for BMI, current smoking status, physical activity, current use of hormonal contraceptives, and recent use of anti-inflammatory medication. Model V adjusts for all family background, educational, and health indicators included in Models II-IV. Model VI adjusts for all family background, educational, and health indicators included in Models II-IV, as well as urbanicity and school size.

Figure 1. Moderating Effect of School Disadvantage on Association between Academic Achievement and High-Risk hs-CRP (N=5,611)

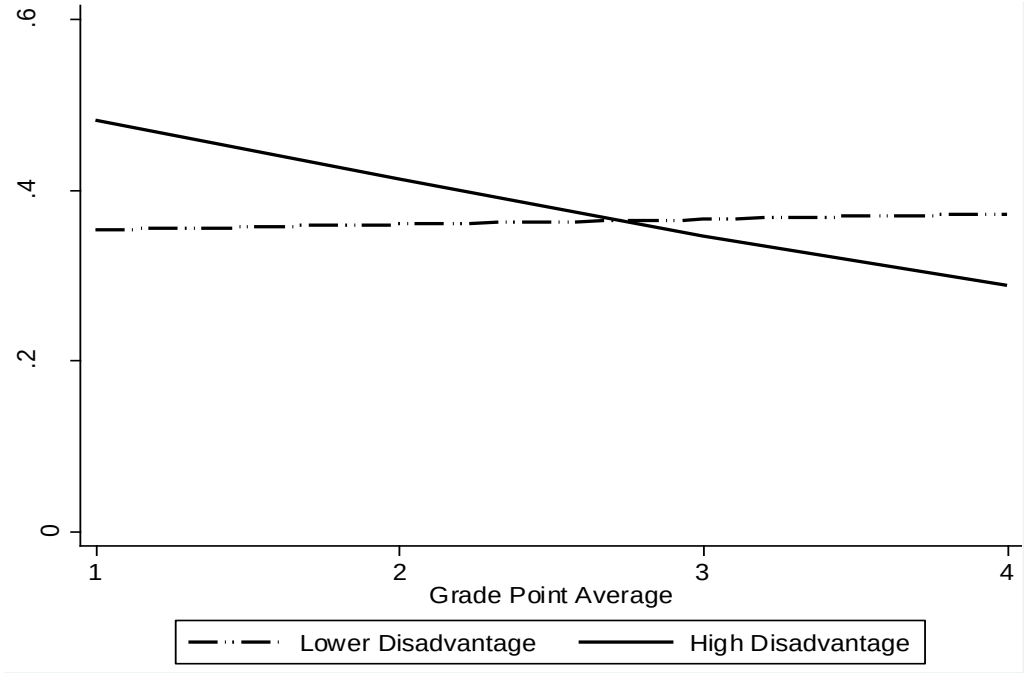
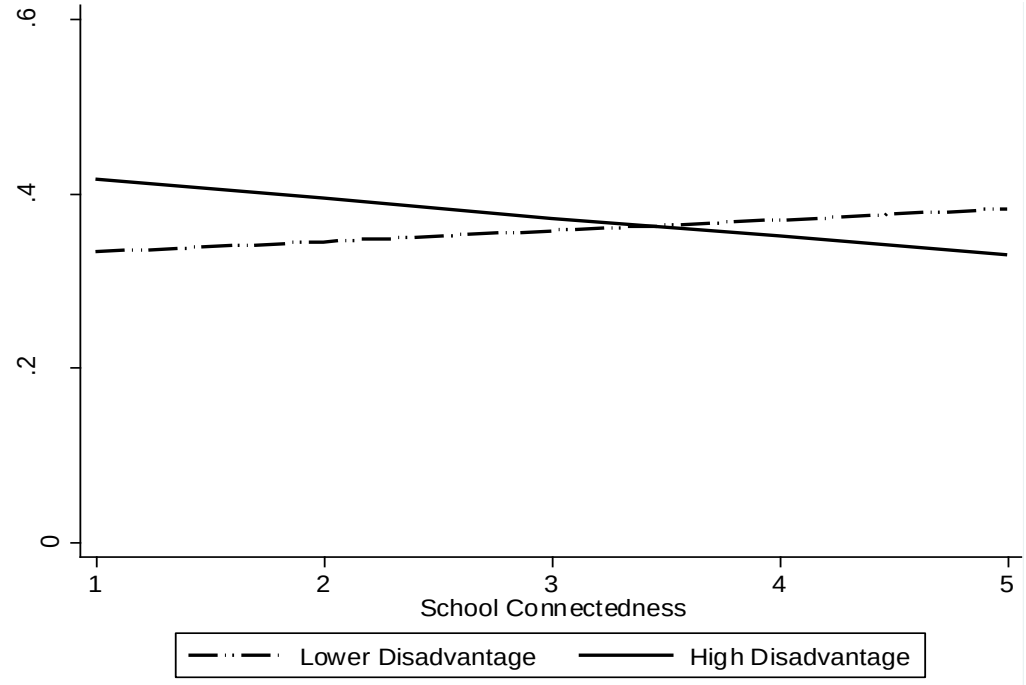


Figure 2. Moderating Effect of School Disadvantage on Association between School Connectedness and High-Risk hs-CRP (N=5,611)



Appendix A: Variables Description

Variable	Items	Coding
Academic achievement	4 items: At the most recent grading period, what was your grade in each of the following subjects: 1) English/Language Arts; 2) Mathematics; 3) History/Social Studies; 4) Science?	1 = "D or lower"; 2 = "C"; 3 = "B" 4 = "A"
Scholastic aptitude	Add Health Picture Vocabulary Test standardized score.	1 = 1st quartile; 2 = 2nd quartile; 3 = 3rd quartile; 4 = 4th quartile
School connectedness	3 items: How strongly do you agree or disagree with each of the following statements: 1) I feel close to people at this school; 2) I feel like I am a part of this school; 3) I am happy to be at this school.	1 = "strongly disagree"; 2 = "disagree"; 3 = "neither agree nor disagree"; 4 = "agree"; 5 = "strongly agree"
School problems	4 items: Since school started this year, how often have you had trouble: 1) getting along with your teachers; 2) paying attention in school; 3) getting your homework done; 4) getting along with other students?	0 = "never"; 1 = "just a few times"; 2 = "about once a week"; 3 = "almost everyday"; 4 = "everyday"
Academic extracurricular activities	French club, German club, Latin club, Spanish club, Book club, Computer club, Debate team, Drama club, Future Farmers of America, History club, Math club, Science club, Band, Chorus/choir, Orchestra, Newspaper, Honor society, Student council, Yearbook, Other club	
Sports teams/extracurricular activities	Baseball/softball, Basketball, Field hockey, Football, Ice hockey, Soccer, Swimming, Tennis, Track, Volleyball, Wrestling, Cheerleading/dance team, Other sport	

Appendix B. Effect of School Experiences on CRP Levels, Full Models (N=5,611)

	Model I	Model II	Model III	Model IV	Model V	Model VI
School experiences						
GPA (ref. D or lower)						
C	0.991	1.019	1.021	0.934	0.957	0.995
	(0.780 - 1.259)	(0.804 - 1.292)	(0.798 - 1.306)	(0.743 - 1.175)	(0.762 - 1.202)	(0.756 - 1.309)
B	0.831*	0.876	0.905	0.883	0.921	0.967
	(0.668 - 1.032)	(0.696 - 1.102)	(0.722 - 1.135)	(0.708 - 1.100)	(0.732 - 1.160)	(0.738 - 1.268)
A	0.694**	0.765*	0.810	0.866	0.921	1.041
	(0.519 - 0.928)	(0.568 - 1.032)	(0.601 - 1.091)	(0.639 - 1.176)	(0.671 - 1.264)	(0.731 - 1.483)
AHPVT (ref. 1st quartile)						
2nd quartile	0.769**	0.792**	0.786**	0.812**	0.828*	0.837
	(0.618 - 0.956)	(0.633 - 0.992)	(0.628 - 0.984)	(0.661 - 0.997)	(0.669 - 1.026)	(0.660 - 1.062)
3rd quartile	0.802**	0.855	0.833*	0.812**	0.836*	0.844
	(0.656 - 0.981)	(0.700 - 1.044)	(0.676 - 1.027)	(0.665 - 0.992)	(0.678 - 1.030)	(0.679 - 1.050)
4th quartile	0.678***	0.757***	0.734***	0.667***	0.706***	0.724***
	(0.553 - 0.831)	(0.613 - 0.934)	(0.594 - 0.908)	(0.544 - 0.819)	(0.561 - 0.889)	(0.569 - 0.922)
School connectedness	1.025	1.030	1.033	1.040	1.040	1.073
	(0.950 - 1.107)	(0.956 - 1.110)	(0.956 - 1.116)	(0.957 - 1.129)	(0.958 - 1.128)	(0.982 - 1.173)
School problems	1.013	1.015	1.002	0.984	0.981	0.994
	(0.950 - 1.080)	(0.953 - 1.081)	(0.940 - 1.068)	(0.922 - 1.052)	(0.918 - 1.048)	(0.924 - 1.069)
School sport clubs (ref. none)						
1-2	0.875*	0.901	0.899	0.907	0.923	0.915
	(0.756 - 1.012)	(0.774 - 1.049)	(0.778 - 1.038)	(0.777 - 1.058)	(0.786 - 1.083)	(0.769 - 1.089)
3+	0.841	0.866	0.868	0.915	0.939	0.919
	(0.670 - 1.057)	(0.694 - 1.081)	(0.690 - 1.092)	(0.724 - 1.157)	(0.743 - 1.188)	(0.707 - 1.195)
School academic clubs (ref. none)						
1-2	0.834**	0.843**	0.854**	0.834**	0.838**	0.807**
	(0.720 - 0.966)	(0.727 - 0.977)	(0.736 - 0.991)	(0.714 - 0.974)	(0.717 - 0.979)	(0.685 - 0.950)

3+	0.922	0.968	0.980	0.996	1.039	0.966
	(0.751 - 1.131)	(0.786 - 1.192)	(0.795 - 1.209)	(0.803 - 1.234)	(0.834 - 1.295)	(0.763 - 1.223)
Demographic controls						
Female	2.201***	2.193***	2.233***	2.594***	2.608***	2.649***
	(1.919 - 2.523)	(1.907 - 2.522)	(1.944 - 2.565)	(2.265 - 2.969)	(2.273 - 2.993)	(2.302 - 3.050)
Race/ethnicity (ref. white)						
Black	1.046	1.020	1.064	0.874	0.877	0.851
	(0.837 - 1.308)	(0.815 - 1.276)	(0.856 - 1.322)	(0.707 - 1.080)	(0.703 - 1.096)	(0.680 - 1.064)
Hispanic	0.974	0.955	0.994	1.002	0.997	1.008
	(0.771 - 1.231)	(0.756 - 1.207)	(0.790 - 1.252)	(0.819 - 1.226)	(0.815 - 1.220)	(0.822 - 1.237)
Other	0.743**	0.772*	0.750**	0.856	0.864	0.868
	(0.568 - 0.974)	(0.577 - 1.032)	(0.573 - 0.981)	(0.660 - 1.110)	(0.657 - 1.136)	(0.666 - 1.132)
Age (Wave IV)	1.015	1.019	1.020	1.009	1.014	1.027
	(0.969 - 1.063)	(0.972 - 1.068)	(0.974 - 1.068)	(0.965 - 1.056)	(0.968 - 1.061)	(0.976 - 1.081)
Family background						
Family income (ref. 1st quartile)						
2nd quartile		0.815			0.799*	0.811*
		(0.634 - 1.048)			(0.635 - 1.006)	(0.641 - 1.026)
3rd quartile		0.835			0.888	0.911
		(0.653 - 1.067)			(0.694 - 1.138)	(0.709 - 1.172)
4th quartile		0.696***			0.700***	0.720**
		(0.556 - 0.871)			(0.538 - 0.911)	(0.550 - 0.941)
Refused		0.774			0.785	0.794
		(0.570 - 1.051)			(0.573 - 1.076)	(0.579 - 1.087)
Missing		1.015			1.115	1.098
		(0.610 - 1.689)			(0.683 - 1.820)	(0.679 - 1.778)
Family structure (ref. 2 bio parents)						
1 bio, 1 step parent		1.094			1.126	1.125
		(0.901 - 1.329)			(0.927 - 1.369)	(0.923 - 1.370)

Other	0.888			0.877	0.882
	(0.734 - 1.074)			(0.724 - 1.063)	(0.727 - 1.070)
Parent educational attainment (ref. high school or less)					
Vocational training	1.110			1.280*	1.288*
	(0.870 - 1.415)			(0.970 - 1.690)	(0.985 - 1.684)
Some college	0.829*			0.997	0.993
	(0.672 - 1.024)			(0.788 - 1.263)	(0.789 - 1.249)
College graduate	0.814*			1.054	1.061
	(0.654 - 1.013)			(0.856 - 1.298)	(0.869 - 1.294)
More than college	0.726***			0.992	0.981
	(0.575 - 0.917)			(0.771 - 1.275)	(0.767 - 1.256)
Born in U.S.	1.193			1.072	1.058
	(0.857 - 1.662)			(0.785 - 1.463)	(0.769 - 1.456)
Parent chose neighborhood for schools	0.959			0.965	0.962
	(0.794 - 1.158)			(0.806 - 1.155)	(0.802 - 1.153)
Educational attainment					
(ref. high school or less)					
Vocational training		1.093		1.077	1.071
		(0.816 - 1.464)		(0.804 - 1.443)	(0.791 - 1.451)
Some college		0.918		0.882	0.897
		(0.737 - 1.144)		(0.694 - 1.121)	(0.703 - 1.144)
College graduate		0.751**		0.925	0.942
		(0.586 - 0.963)		(0.693 - 1.234)	(0.705 - 1.260)
More than college		0.640***		0.849	0.851
		(0.480 - 0.853)		(0.604 - 1.193)	(0.602 - 1.201)
Health status & behaviors					
BMI			1.139***	1.139***	1.139***
			(1.123 - 1.155)	(1.123 - 1.155)	(1.123 - 1.156)

Current smoker	1.089	1.043	1.026
	(0.906 - 1.308)	(0.874 - 1.243)	(0.855 - 1.230)
Physical activity (ref. none)			
1-3 times a week	0.864	0.877	0.868
	(0.695 - 1.075)	(0.704 - 1.092)	(0.696 - 1.083)
4+ times a week	0.772***	0.789***	0.782***
	(0.645 - 0.925)	(0.660 - 0.942)	(0.655 - 0.933)
Hormonal contraceptives	1.219**	1.233***	1.234***
	(1.044 - 1.423)	(1.055 - 1.441)	(1.058 - 1.441)
Anti-inflammatory medications	1.260***	1.255***	1.252***
	(1.077 - 1.474)	(1.069 - 1.474)	(1.066 - 1.471)
School-level main effects			
High school disadvantage			2.498**
			(1.062 - 5.873)
Urbanicity (ref. suburban)			
Urban			0.977
			(0.815 - 1.172)
Rural			0.906
			(0.768 - 1.069)
School size (ref. 1-400 students)			
401-1000 students			0.958
			(0.775 - 1.184)
1001-4000 students			0.873
			(0.711 - 1.074)
Cross-level interactions			
GPA x High disadvantage			
(ref. D or lower x Low disadvantage)			
C x High disadvantage			0.844
			(0.548 - 1.301)
B x High disadvantage			0.764

	(0.495 - 1.180)
A x High disadvantage	0.327***
	(0.165 - 0.649)
AHPVT x High disadvantage	
(ref. 1st quartile x Low disadvantage)	
2nd quartile x High disadvantage	1.041
	(0.635 - 1.708)
3rd quartile x High disadvantage	1.110
	(0.602 - 2.048)
4th quartile x High disadvantage	0.911
	(0.451 - 1.841)
School connectedness x High disadvantage	0.808**
	(0.662 - 0.986)
School problems x High disadvantage	0.994
	(0.924 - 1.069)
Sport clubs x High disadvantage	
(ref. none x Low disadvantage)	
1-2 x High disadvantage	0.981
	(0.657 - 1.464)
3+ x High disadvantage	1.037
	(0.560 - 1.920)
Academic clubs x High disadvantage	
(ref. none x Low disadvantage)	
1-2 x High disadvantage	1.293
	(0.807 - 2.073)
3+ x High disadvantage	1.576
	(0.866 - 2.870)

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